DRILLING OF AND SEISMIC MEASUREMENTS FROM BOREHOLES WHILE CHARACTERIZING THE WEEKS ISLAND SALT DOME

by

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Six boreholes were drilled for purpose of geologic characterization and diagnostics of a sinkhole that developed over the salt mine converted for oil storage by the U. S. Strategic Petroleum Reserve. The primary purpose of the four vertical holes was to provide the geometry for cross-well seismic tomography across the sinkhole to learn about the sinkhole collapse structure, secondarily to obtain wireline core through the unstable overburden and salt, and to obtain geophysical logs. The goal of one of the slant holes was to penetrate the overburden, and core through normal salt into the sinkhole and the second slant hole was to penetrate under the surface expression of the sinkhole.

The requirements for the seismic holes sometimes conflicted or those for wireline coring: hole spacing, (close enough to receive signals, far enough from the sinkhole for a drill rig), minimum hole ID (big enough for transmitter and receiver to fit and be interchanged (impacting the wireline coring), the avoidance, if possible, of nested tubulars in the well (making wireline coring contingencies difficult). The surface owner, Morton International, required successful cementing through the alluvium and a 250 ft vertical depth limitation on the wells was agreed upon.

Crosswell seismic data were generated across the sinkhole along two separate vertical imaging planes. As crosswell data were taken, simultaneous recordings were made from surface geophones. Chevron's clamped borehole seismic vibrator was the energy source for both sets of measurements. A multi-station borehole seismic receiver system, developed by Sandia and OYO Geospace, was used to record the crosswell data. Data acquisition from the crosswell and reverse VSP profiles led to the production of 3D tomograms. These velocity images suggest the sinkhole collapse is complicated, not a simple vertical structure. The sinkhole structure appears to have asymmetric wings along at least one azimuth through the sinkhole.

The coring operation was moderately difficult. Limited core was obtained through the alluvium and the quality of the salt core from the first two vertical wells was poor. Core quality improved with better bit selection. The drilling fluid program provided fairly stable holes allowing open hole logs to be run. All holes were cemented successfully, but it took three attempts in one case.

A remarkable result from one slant hole was coring through normal salt and penetrating into the sinkhole throat. Drilling of this slant hole was to be shut down when either: (1) the sinkhole was penetrated, or, (2) when a total vertical depth of 250 **ft** was reached. Total vertical depth when the sinkhole was penetrated was 249.1 ft.

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U. S. DEPARTMENT OF ENERGY GEOTHERMAL DIVISION LOST CIRCULATION TECHNOLOGY DEVELOPMENT

(DOWNHOLE TOOLS AND MATERIALS FOR TREATING LOSS ZONES)

by

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Lost circulation is a problem common to both the geothermal and the solution mining-industry. In both cases, drilling is on a relatively large scale (geothermal holes can be as large as 26 inches). Lost circulation technology development has been in progress at Sandia National Laboratories for more than 15 years. The initial work centered on lost circulation materials but testing and modeling indicated that if the aperture of a loss zone is very large (larger than the drill bit nozzles) it cannot be plugged by simply adding materials to the drilling fluid. Thus, the lost circulation work evolved to include:

- Development of metering techniques that accurately measure and characterize drilling fluid inflow and outflow for rapid diagnosis of lost circulation or and fluid balance while drilling.
- Construction of a laboratory facility for testing drillable straddle packers (to improve the plugging efficiency of cementing operations) and the actual testing of components of the straddle packer.
- Construction of an Engineered-Lithology Test Facility (ELTF) to test straddle packers etc. under full scale test conditions, and for testing conventional cementing practices to learn more, via mine-back, about characteristics of cement flowing from an-open-end drill pipe into a large-diameter wellbore.
- Construction of a laboratory facility for the testing of actual candidate porous fabrics as a part of a program to develop a porous packer that places foam into a loss zone.
- Implementing (with Halliburton, and CalEnergy Company) a program to test a non-cementitious plug material to stem lost circulation.

Rapid and accurate diagnosis of lost circulation while drilling is necessary to minimize fluid loss, reduce treatment costs, and save rig time. A rolling float meter was built, tested and partially commercialized for use in monitoring fluid outflow in partially filled return line pipes. A new generation of commercial Doppler flow meters have been purchased and tested in monitoring drilling inflow rates. Together these flow meters have been used in the laboratory and field to accurately monitor fluid balance and detect lost circulation while drilling. Also, an expert system is being developed to detect lost circulation.

The drillable straddle packer is designed to maximize the volume of cement that flows into the loss zone, to minimize the volume of cement remaining in the borehole, and to reduce dilution of cement from other wellbore fluids flowing into the formation. Its development is essentially complete. The next step is to test a prototype with cement in the ELTF early this summer. The 15 ft x 15 ft x 15 ft ELTF test chamber will be loaded with alternating layers of gravel and clay to simulate impermeable rock and loss zones respectively. Facility piping will be used to flow water into and out of the gravel beds to model loss and production zones.

Testing of candidate porous fabrics for the wireline porous packer has been completed. While development of the porous packer follows that of the straddle packer, much of the packer technology (bag fabrication, shroud development and deployment, decoupling from a wireline or drill string) will have applicability to the porous packer concept.

The non-cementitious plug material hardens faster than conventional cement, drills faster, and is chemically compatible with the drilling fluid, thereby potentially reducing loss-zone, cementing, and mud conditioning costs. The first field trial showed promise and in certain instances saved several hours of rig time compared to conventional methods. The material was reformulated and will be tested this fall.

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